

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



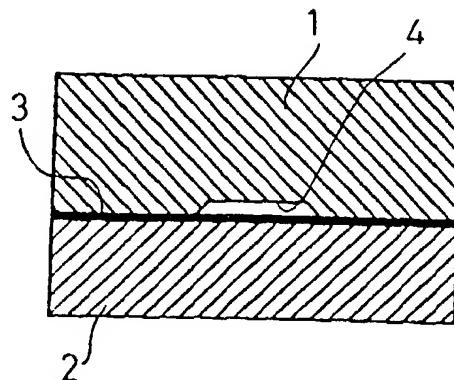
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification<sup>5</sup> :</b> <b>C09J 5/06, G01N 30/60</b>		<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 94/29400</b> <b>(43) International Publication Date:</b> 22 December 1994 (22.12.94)
<b>(21) International Application Number:</b> <b>PCT/SE94/00584</b> <b>(22) International Filing Date:</b> 14 June 1994 (14.06.94)		<b>(81) Designated States:</b> JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
<b>(30) Priority Data:</b> 9302051-9 15 June 1993 (15.06.93) SE		<b>Published</b> <i>With international search report. In English translation (filed in Swedish).</i>	
<b>(71) Applicant (for all designated States except US):</b> PHARMACIA LKB BIOTECHNOLOGY AB [SE/SE]; S-751 82 Uppsala (SE).			
<b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> ÖHMAN, Ove [SE/SE]; Asplunda, Uppsala-Näs, S-755 91 Uppsala (SE).			
<b>(74) Agents:</b> WIDÉN, Björn et al.; Pharmacia AB, Patent Dept., S- 751 82 Uppsala (SE).			

**(54) Title:** METHOD OF PRODUCING MICROCHANNEL/MICROCAVITY STRUCTURES

**(57) Abstract**

In a method of forming a microchannel and/or microcavity structure by bonding together two elements (1, 2) having opposed plane surfaces of the same or different materials, one or both surfaces having open channels and/or cavities, bonding is effected by applying to one or both element surfaces (1, 2) a thin layer (3) of a solution of a material capable of fusing with and having a lower melting point than that of the material or materials of the two element surfaces (1, 2) in a solvent which substantially does not dissolve the element surface material or materials. The solvent is then removed, and the two elements (1, 2) are brought together and heated to a temperature where the dissolved material is caused to melt but not the element surface material or materials.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

**METHOD OF PRODUCING MICROCHANNEL/MICROCAVITY STRUCTURES**

The present invention relates to the production of microchannel and microcavity systems, and more particularly 5 to an improved method of bonding plane layers together in such production.

Microchannel or microcavity structures are used in inter alia chemical analytical techniques, such as electrophoresis and chromatography. In one type of such 10 microfluidic structures, a channel and/or cavity system is defined between two plane material layers, the recesses which correspond to the channels and cavities, respectively, being formed in one or both of the opposed layer surfaces. The layers are usually bonded together by 15 gluing. Alternatively, if the two layers consist of thermoplastic material, they may be fused together by the application of heat.

When very small channel dimensions are concerned, however, these conventional joining methods tend to deform 20 the channel or cavity system to a great extent by partial clogging with glue or molten material.

The object of the present invention is to overcome this problem by providing a method which permits convenient bonding together of the material layers substantially 25 without affecting the channel or cavity system.

According to the invention, this is achieved by a method of production which has the features defined in claim 1. Preferred embodiments are defined in the subclaims.

30 The invention is based on the concept that in order to bond together two planar element surfaces of the same or different materials, preferably thermoplastic, which surfaces when brought together define a channel and/or cavity system between them, there is applied to one or, 35 preferably, both element surfaces a thin layer of another, preferably also thermoplastic, material dissolved in a solvent which does not dissolve the material of the two element surfaces. This dissolved material should, on one

hand, be capable of being fused with the material(s) of the two surfaces on which it has been coated, and, on the other hand, melt at a lower temperature than the melting temperature of the element surface material or materials.

5 After evaporation of the solvent, the two surfaces are brought together, e.g. by rolling, whereupon the assembly is heated to a temperature that melts the intermediate (preferably thermoplastic) material but not the material of the element surfaces for effecting joining of the two

10 element surfaces.

The applied solution layer should, of course, have a very small thickness in relation to the width and depth of the channels and microcavities, respectively, which width and depth may be of the order of magnitude of 50 to 100  $\mu\text{m}$ ,  
15 for example.

When a thermoplastic material is used for the two material surfaces, this thermoplastic material is suitably closely related to the thermoplastic material responsible for the bonding of the channel/cavity structure. As an 20 example of a suitable type of thermoplastic for the present purpose may be mentioned fluoroelastomers.

Suitable combinations of surface/bonding materials and solvents for practising the invention will readily be devised by the person skilled in the art guided by the 25 present description.

The carrying out of the process of the invention is illustrated schematically in the accompanying drawings, wherein Figs. 1A to 1C show different substeps in the manufacture of a microfluidic structure, and Fig. 2 is a 30 cross-section of the final product.

Fig. 1A shows a plate 1 provided with an open channel system (not shown), which plate together with an identical plate 2 without the channel system is intended to define a microchannel system between the two plates. For bonding the 35 two plates together, which preferably are made of a thermoplastic material, e.g. a fluoroelastomer, a thin layer 3 of a, preferably closely related, thermoplastic material, e.g. a modified fluoroelastomer with a lower

melting point, is first spun onto both plate surfaces. Then the solvent is baked off at an increased temperature (e.g. 135 °C), as is illustrated in Fig. 1B. The two plates treated in this way are then rolled together, as indicated 5 in Fig. 1C, and are allowed to be bonded together for some time, e.g. 5 minutes. The completed microchannel structure is shown in Fig. 2. As may be seen from the latter figure, the two plates 1, 2, which are held together by the material layer 3, define a channel system 4 between them.

10 The following specific Example, which describes the production of a microchannel structure, illustrates the method of the invention further.

#### EXAMPLE

15 A polymer structure with closed straight channels having a height of 50  $\mu\text{m}$ , a width of 250  $\mu\text{m}$  and a length of about 80 mm was produced in the following manner.

A silicon mould having a surface relief structure corresponding to the desired channel geometry was manufactured in per se known manner. Thus, the surface of a 20 silicon plate was first oxidized at about 1100 °C to form an oxide layer of 8000 Å thickness. After washing, dehydration in an oven and priming with hexamethylsilane, a photoresist layer was spun onto the oxide layer and was stabilized by baking in an oven. A mask corresponding to 25 the desired channel pattern was then placed on the plate surface, and the surface parts not covered by the mask were exposed to light. The exposed photoresist parts were then removed by developing solution to bare the oxide layer, and the remaining photoresist was hard-baked. The bared oxide 30 was then etched with hydrofluoric acid/ammonium fluoride to expose the silicon (the backside of the plate being protected by resistant tape), whereupon the photoresist mask was removed by acetone. The oxide-free silicon surfaces were then etched with potassium hydroxide solution 35 for a sufficient time to produce the desired etch depth. The resulting surface exhibited the desired channel pattern.

The silicon mould obtained was then pressed against a 2 mm thick film of Hostaflon TFB 7100 (refractive index about 1.36) at about 160 °C and 20 kp/cm<sup>2</sup>. (Hostaflon is a thermoplastic fluoroelastomer sold by Hoechst AG, Germany).

5 The resulting channel structure was bonded to a base layer in the form of a plane plate of the same material by spinning a thin layer of Hostaflon TFB X-7200 (having a lower melting point than that of Hostaflon TFB 7100) dissolved in propylmethylketone onto the base layer and the

10 channel structure, which were then allowed to dry at 130 °C for 10 minutes. The channel structure and the base layer were then immediately rolled together, and the obtained sandwich was baked at about 140 °C for 10 minutes. The polymer structure produced in this way exhibited intact

15 closed channels.

The invention is, of course, not restricted to the embodiment described above and specifically shown in the drawing, but many modifications and changes may be made within the scope of the general inventive concept as it is 20 stated in the following claims.

## CLAIMS

1. A method of forming a microchannel and/or microcavity structure by bonding together two elements (1, 2) having opposed plane surfaces of the same or different materials, one or both surfaces having open channels and/or cavities, characterized in that said bonding is effected by applying to one or both element surfaces (1, 2) a thin layer (3) of a solution of a material capable of fusing with and having a lower melting point than that of the material or materials of the two element surfaces (1, 2) in a solvent which substantially does not dissolve the element surface material or materials, removing the solvent, bringing the two elements (1, 2) together, and heating to a temperature where the dissolved material is caused to melt but not the element surface material or materials.
2. The method according to claim 1, characterized in that the two elements (1, 2) that are to be bonded together are of the same material.
3. The method according to claim 1 or 2, characterized in that the dissolved material (3) is thermoplastic.
4. The method according to any one of claims 1 - 3, characterized in that the material of the two elements (1, 2) is thermoplastic.
5. The method according to claim 4, characterized in that the material of the two elements (1, 2) and the dissolved material (3) are of substantially the same type.
6. The method according to claim 5, characterized in that the materials of the two elements (1, 2) and the dissolved material (3) are fluoroelastomers.

1 / 1

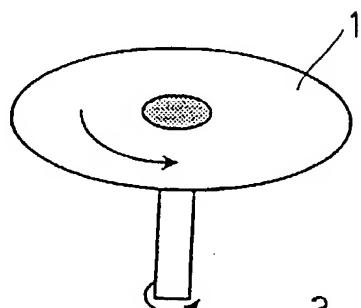


FIG. 1A

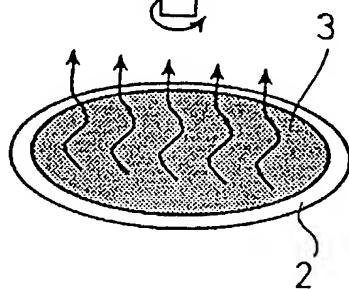


FIG. 1B

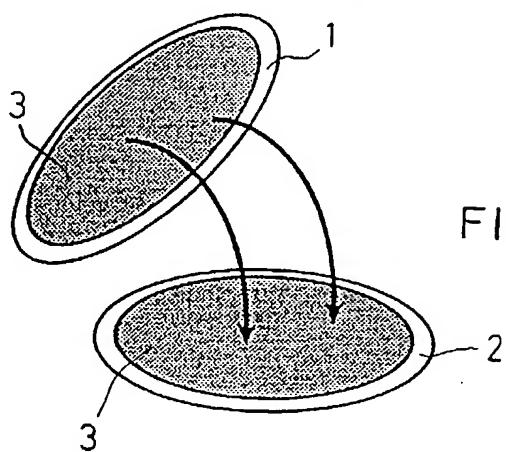


FIG. 1C

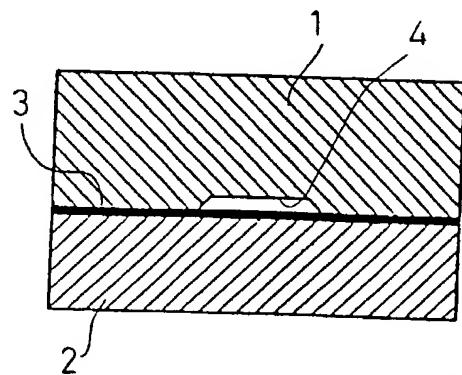


FIG. 2

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00584

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: C09J 5/06, G01N 30/60

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: C09J, G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, PAJ, WPI

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE, A1, 4128964 (FOTOCHEMISCHE WERKE GMBH), 4 March 1993 (04.03.93) -----	1-5

<input type="checkbox"/>	Further documents are listed in the continuation of Box C.	<input checked="" type="checkbox"/> See patent family annex.
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	

Date of the actual completion of the international search  22 Sept. 1994	Date of mailing of the international search report  26 -09- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer  Sofia Nikolopoulou Telephone No. + 46 8 782 25 00

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

27/08/94

International application No.

PCT/SE 94/00584

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A1- 4128964	04/03/93	NONE	